Deeter Wireless Sensor System
User Manual

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Contents

1. Summary 3
2. The Deeter Wireless Sensor System 5
2.1 System Devices 5
2.2 System Applications and Features 6
2.3 RF Communications 6
2.4 Wireless Range 6
2.5 System Setup Options 7
2.6 Wireless Base Station 8
2.7 Wireless Sender 9
2.8 LVCS-RF 10
2.9 Wireless Router 11
3. Installation 12
3.1 Base Station Wiring and Setup 12
3.2 Wiring the Sender 17
3.3 Fitting the LVCS-RF 18
3.4 Placing a Router 19
3.5 Antenna Location 19
3.6 Antenna Installation Precautions 20
3.7 Registering Network Devices 20
3.8 Network Testing 21
3.9 Setting the Transmit Interval 22
3.10 Analogue Calibration 23
3.11 Low Battery Indication 23
3.12 Loss of Radio Link 24
4. Specifications 25
4.1 Wireless Base Station 25
4.2 Wireless Sender 26
4.3 LVCS-RF Continuous Liquid Level Sensor Transmitter 27
4.4 Wireless Router 28
5. Warnings 29
5.1 Replacing Batteries 29
5.2 Fuses 29
5.3 Antenna 29
5.4 CE Marking 29
5.5 FCC Part 15 Compliance 29
5.6 RF Exposure Compliance 30
5.7 Repair and Servicing 30
5.8 Disposal and Recycling 30
6. List of Acronyms and Abbreviations 30

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1. Summary

The Deeter Wireless Sensor System consists of a remote sensor node that transmits data over an RF network to a Base Station.

The sensor nodes enable remote wireless sensing of:

- Switch inputs
- Analogue resistive sensor inputs
- 4-to-20mA current loop circuits

The Base Station receives sensor signals and converts these to the following outputs:

- Open-collector transistors for controlling a wide range of devices
- A 4-to-20mA current-loop driver

The system communicates using the IEEE 802.15.4™ wireless network protocol, in the 2.4GHz ISM frequency band. This is an internationally approved, licence free radio band, with no subscription or operating charges.

This User Manual introduces the system components, explains how to install and setup a system, and includes specifications and product information.

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Figure 1: Base Station, Router, Sender

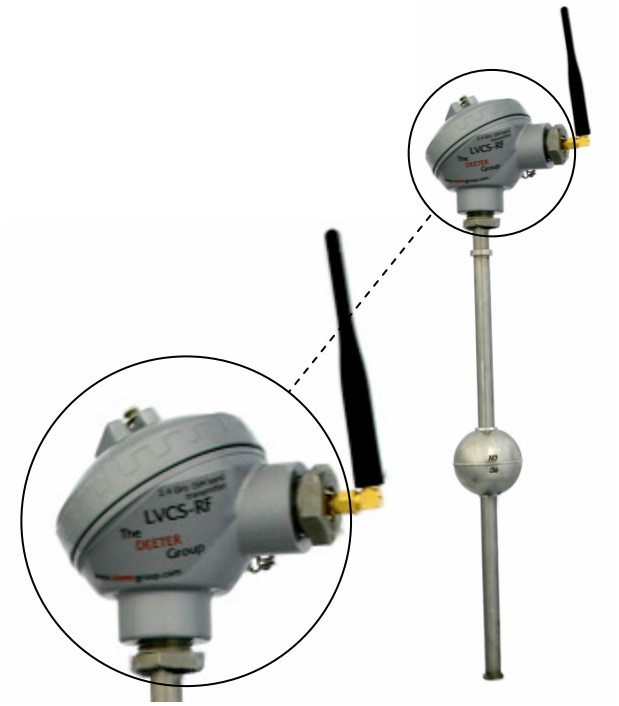

Figure 2: LVCS-RF

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2. The Deeter Wireless Sensor System

2.1 System Devices

There are four devices in the Deeter Wireless Sensor product range:

- Base Station
- Wireless Sender
- LVCS-RF
- Wireless Router

The basic wireless sensor system comprises a Base Station and a single sensor node, either a Sender or LVCS-RF. A Router may be added to the system to improve communications reliability or to extend the wireless range. Up to four Routers may be used in a single system.

The sensor nodes can accept a range of input devices to suit the application:

- Four switch inputs (Sender only)
- An analogue resistive input (Sender and LVCS-RF)
- A 4-to-20mA current-loop sensing input (Sender only)

Figure 3: Wireless Sender with 40-Series Float Switches and LVCS

Figure 3 illustrates a possible arrangement of inputs to a Sender with four Deeter 40-Series Level Switches and a Deeter continuous level sensor.

The Base Station has a range of outputs to drive a wide variety of possible devices:

- Four open-collector transistors
- 4-to-20mA current loop driver
- Serial communications output via RS232, RS485 or USB

  (At present, serial communications is reserved for diagnostic data. Future developments are expected to include data-logging features.)

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2.2 System Applications and Features

The system was primarily designed for use in liquid level sensing, to complement the range of Deeter float-switches and continuous level sensors. Countless other applications are possible, including:

- remote monitoring of switch inputs to drive relay outputs
- converting a potentiometer input to a 4-to-20mA current loop output
- mirroring a 4-to-20mA current loop signal
- switching relays at preset input thresholds

The System has the following advanced features:

- Sophisticated RF Communications and Wireless Network capability
- Fully automatic operation once the system is installed
- Battery powered remote sensors

2.3 RF Communications

The system uses high power RF transceiver modules and external antennae to achieve the best communications range. Range can be further extended by adding one or more Deeter Wireless Routers.

The Base Station acts as the coordinator for the wireless network, operating in the 2.4GHz ISM (Instrumentation Scientific and Medical) frequency band. This allows the system to be used world-wide without requiring a site radio operating licence. (Local regulations may restrict the maximum RF transmit power and Deeter provide different variants of the Wireless System devices for the US, Canadian and European markets to satisfy these constraints).

The IEEE 802.15.4 protocol allows several networks to share the same frequency without interfering with each other. The protocol uses sophisticated techniques to ensure good communications using very low power signalling. This allows the Deeter Wireless Sender or LVCS-RF to operate using battery power.

Once the system is installed it should operate without any further intervention. When several Routers are used they form a 'mesh' network, and signals can be re-routed around any broken links in the mesh. Thus, the system has a built-in self-healing capability, to further ensure communications reliability.

2.4 Wireless Range

At maximum transmission power (US version) the distance between sensor node and Base Station may be up to 4km in an ideal, open field installation. (European regulations restrict the maximum power and a range of up to 1000m may be attained). However, in most practical environments the radio signal will be attenuated by obstructions and by multi-path fading caused by reflections. To improve range, a clearer signal path can often be achieved by increasing the height of the antenna. Deeter supply an antenna extension kit for this purpose.

A Deeter Wireless Router placed somewhere between the remote sensor and Base Station, or off to one side of the direct line between the two, will greatly extend the wireless range. Up to four Routers may be used in a single system.

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2.5 System Setup Options

System parameters are selected during installations using the Base Station display menus. Parameters that are controlled by the sensor node are transferred by radio signal from the Base Station and saved in non-volatile memory at the sensor node. Parameters include:

- Sensor update frequency
- Output assignments and set-point thresholds
- Initial RF Channel
- RF power

The sensor update frequency is how often the sensor node makes a measurement and transmits readings to the Base Station. There are seven user-selectable frequencies from once-per-second to once every 60 seconds. A slow update rate will improve battery life for a battery-powered sensor.

Each transistor output on the Base Station can be assigned to either a switch input at the sensor node or a set-point of the analogue input. If a set-point is selected, there is also the option to choose whether to turn on the output above or below this set-point. There is also the option to add hysteresis by having two set-points, one as an on-threshold and the others as an off-threshold.

The Deeter Wireless System can operate on any of the 16 RF channels in the 2.4GHz ISM band. The initial channel can be selected at the Base Station if the user has a preference e.g. if they know which channels are less prone to interference from other equipment using the ISM band. If set to 'Auto' the Base Station will scan all channels and select the one with the least background activity at that time. This initial channel may change automatically later if the system experiences poor communications – there will be a temporary loss of communications over the network while a new channel is established. The sensor node and Routers will automatically re-assign to the channel selected by the Base Station and will find the Base Station if the channel changes.

The default RF power setting is 6dBm which is the maximum setting for compliance within Europe. Lower settings are available for installation testing purposes (see *Network Testing*), but the default will be restored on a device reset. US versions will allow the RF power to be raised to 18dBm and these higher settings will be restored after a reset.

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2.6 Wireless Base Station

Figure 4: Base Station

A Base Station is required in all systems. It receives data from a remote sensor node (either Sender or LVCS-RF) and converts these signals into useful process outputs. Each Base Station has:

- Four open-collector transistor outputs capable of sinking up to 50mA at 40V
- One 4-to-20mA current loop driver

The Base Station has a user-interface consisting of three push-button switches, four LED indicators and a 2-line by 16-character liquid crystal display. The buttons and LEDs are only accessible with the lid removed and are used in conjunction with the display to select a variety of output and installation options during initial setup. During normal operation the display shows various system parameters such as radio link quality and sensor node battery level.

The Base Station is housed in an ABS enclosure with clear polycarbonate window for viewing the display. It has an external antenna and three cable glands for power input and signal outputs. It can be powered by a supply between 12 and 24Vdc – a 12Vdc switch-mode mains adapter is supplied. A wall mounting kit is also supplied.

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2.7 Wireless Sender

Figure 5: Wireless Sender

The Wireless Sender has three input types:

- Four switch inputs
- An analogue resistive input
- A 4-to-20mA current loop sensing input

Only one of the analogue inputs (resistive and current loop) can be used at a time, selected by jumper link.

The analogue resistive input is designed for low-powered operation with a Deeter LVCS (Liquid Vertical Continuous Sensor) but can operate with other resistive sensors, such as Wheatstone bridges and potentiometers.

The Sender requires no user interaction during normal operation. It has an on/off switch and an LED, both only accessible with the lid removed. The LED provides an indication of the status of the wireless link to the Base Station.

The Sender has 4 power supply options:

- Mains only – via a 5Vdc switch-mode mains adapter, supplied
- Battery only – 3.6V Lithium Thionyl Chloride, size AA, supplied (‘C’ size optional)
- Mains + Battery
- Battery + 4-to-20mA power scavenging

When a mains power adapter is fitted, the battery is only required during power outages. Switch-over between the two power sources is automatic.

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If a 4-to-20mA current loop input is being monitored, power can be derived from the current loop to provide all that the Sender needs during normal operation, thus the life of the battery can be greatly extended. The battery will be called upon to assist during start-up and to re-establish a link if there is a break in wireless communications.

The Sender is housed in an ABS enclosure with an external antenna and two cable glands for power and signal inputs. A wall mounting kit is supplied. An optional extension lead and bracket kit is also available for mounting the antenna in a position more favourable to wireless communication.

2.8 LVCS-RF

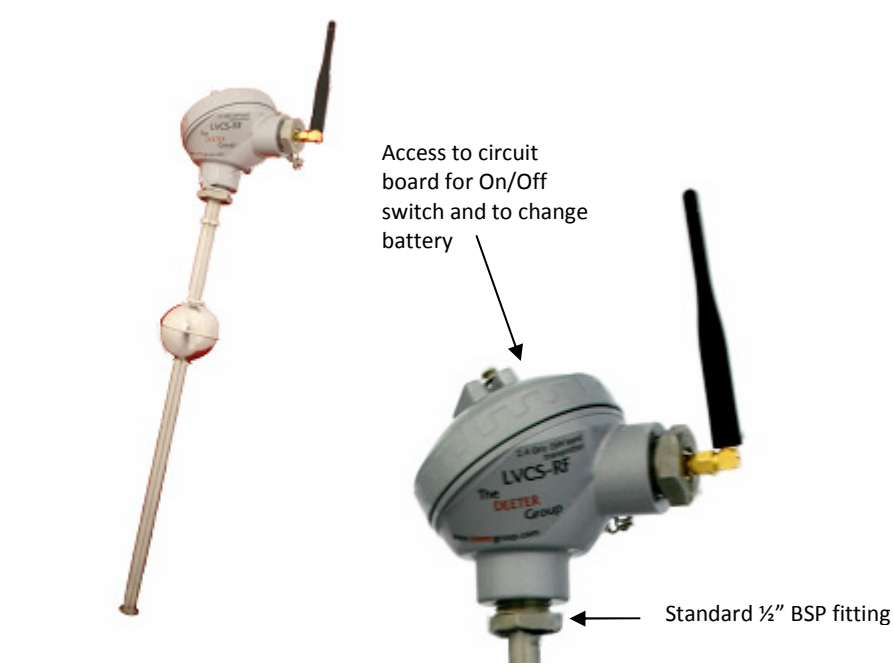

Figure 6: LVCS-RF

The Deeter LVCS (Liquid Vertical Continuous Sensor) uses a magnetic ball-float that can travel up and down a tube immersed in a tank, to measure fluid level. Standard versions are available with 4-to-20mA output, analogue voltage output and analogue resistive output. The LVCS-RF is a wireless version, battery operated and requires no external cabling.

The electronic circuit is a cut-down version of the Sender with only the analogue resistive input and a battery power supply (½AA, 3.6V Lithium Thionyl Chloride). The reduced circuit size allows it to fit inside an aluminium alloy head that fits to the outside of the tank.

The standard sensing circuitry is housed in a stainless steel tube with a 55mm diameter stainless-steel ball-float and a sensing resolution of 5mm. Standard sensing lengths are 250mm, 500mm, 750mm and 1000mm. Custom lengths, alternative materials, alternative floats and other resolutions are available on request.

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The antenna is supplied mounted to the head. An optional extension lead and bracket kit is available for mounting the antenna in a position more favourable to wireless communication.

The LVCS-RF requires no user interaction during normal operation. There is an on/off switch and an LED, only accessible with the head top unscrewed. The LED provides an indication of the wireless link to the Base Station during setup.

Note that a Sender using the analogue resistive input is functionally the same as an LVCS-RF. The Sender has the advantage of a range of power supply options and a longer battery life. The LVCS-RF has the advantage of being integrated with the LVCS sensing circuit in the more compact aluminium alloy head and without the need for any external wiring.

2.9 Wireless Router

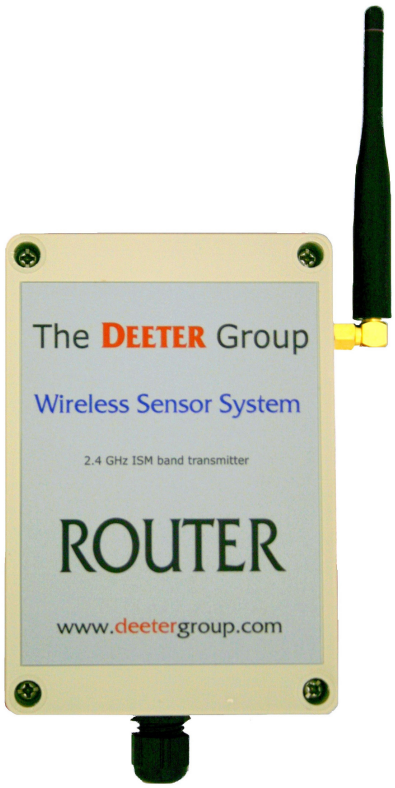

Figure 7: Wireless Router

A Deeter Wireless Router is required in systems where the remote sensor and Base Station are beyond the range of direct point-to-point transmission. A Router can greatly improve signal confidence when the wireless signals are weak due to obstructions in the direct path, interference from moving objects or changing environmental conditions. Up to four Deeter Wireless Routers can be used in a system.

The Router is housed in an ABS enclosure with an external antenna and a cable gland for power input from a switch-mode 5Vdc mains adapter (supplied). A wall mounting kit is also supplied. An optional extension lead and bracket kit is available for mounting the antenna in a position more favourable to wireless communication.

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3. Installation

3.1 Base Station Wiring and Setup

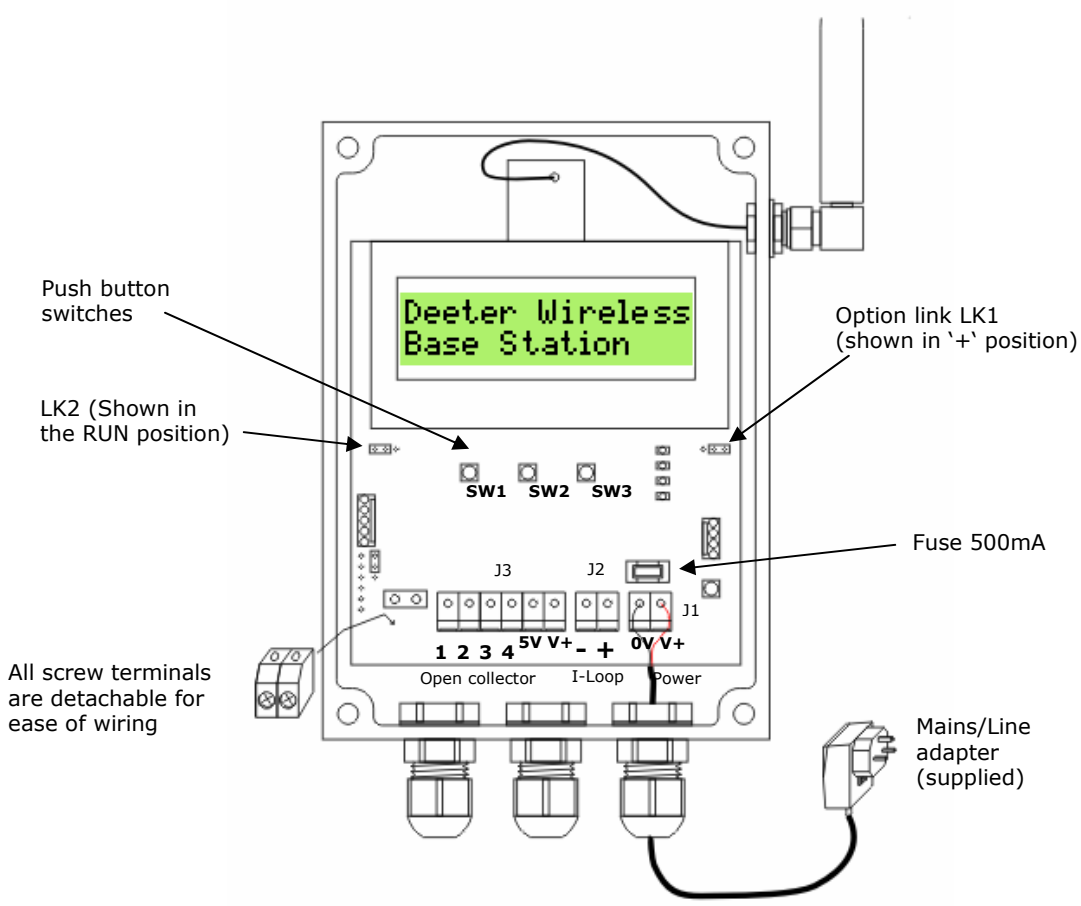

Figure 8: Wiring the Base Station

3.1.1 Power

The Base Station is powered from an external DC power supply. A wall mounted 12V DC power switch-mode mains adapter is supplied. If the current loop transmitter is to drive a heavy load then the Base Station can be supplied with up to 24V DC.

Connect the external supply to terminal block J1. Connect the positive wire from the power supply (identified by a red sleeve on the supplied mains adapter) to the +V terminal.

The power input is protected by a 500mA fuse (F1).

3.1.2 Process Inputs

All process inputs to the Base Station are received from remote sensor nodes by radio.

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3.1.3 Process Outputs

The Base Station has two types of output; open-collector transistors and a 4-to-20mA current loop output. Screw terminals are provided and care must be taken to observe the correct polarity of signals, which are labelled on the PCB.

Connect the current loop circuit to J2. If the devices on the current loop circuit add up to a high resistance (>350 ohms), a higher voltage power supply may be required.

The open-collector outputs are on J3 and are suitable for voltages of up to 40V DC in the off state and will sink up to 50mA in the on state. Typical uses are to drive relays, indicator lamps, PLC inputs, etc. These outputs are short-circuit protected but should not be exposed to a continuous fault condition.

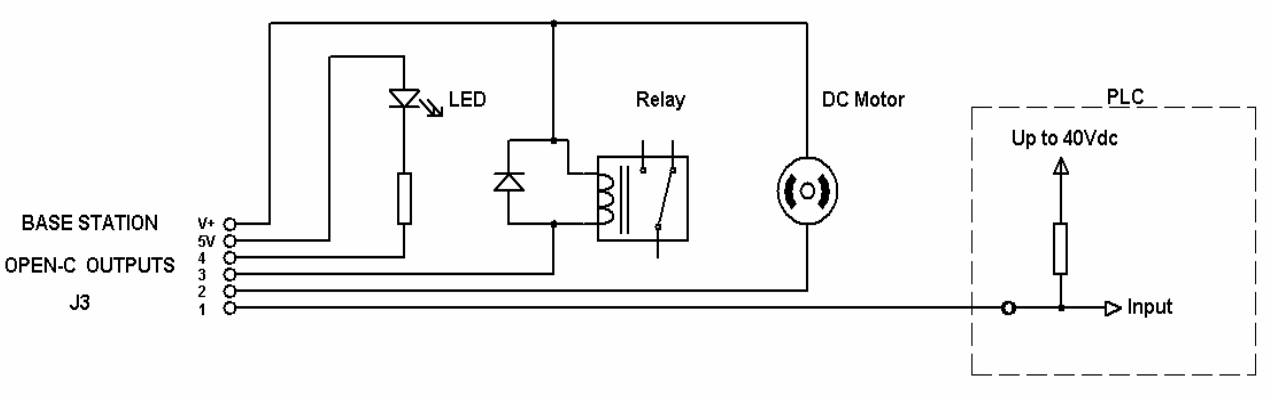

Figure 9: Example transistor output connections

J3 has two supply outputs that may be used to power external devices and act as pull-ups for the transistor open-collectors. The '5V' pin provides a regulated 5V output and the 'V+' pin is derived from the power supply input and can be up to 24Vdc. The total current that can be drawn is limited by the 500mA fuse.

3.1.4 Option links

Jumper link LK1 is used in the '–' position to enable additional menu options that allow previous network settings to be cleared from non-volatile memory. In normal use the link should be in the '+' position (or removed). In this position the unit will auto start when power in applied and auto restart after a temporary power interruption.

Link LK2 is used for programming software updates. This should be left in the 'RUN' position (or not fitted).

(Link LK3 enables or disables 120 ohm termination for the RS485 interface and is for future use.)

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3.1.5 Output Configuration Setup

Remove the lid of the enclosure to gain access to the three push-button switches. In general, SW1 (the left switch) selects the next menu, SW2 (middle switch) changes settings or selects available options, and SW3 (the right switch) saves new settings and options.

To configure Base Station outputs:

- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup.
- Press SW1 to get to the 'Output Settings' screen.
- Pressing SW2 will toggle between 'Enable' and 'Disable'.

Selecting 'Disable' will force outputs to the default settings – transistor outputs 1 to 4 will mirror the Sender inputs 1 to 4 and the 4-to-20mA output will mirror the analogue input of the sensor node (Sender or LVCS-RF). Selecting 'Enable' will allow further menus to set alternative output options. Assuming 'Enable' is selected…

- Press SW1 to reach the 'Output #1' menu.
- Pressing SW2 will cycle through the options for output 1:
    - = IN1 output mirrors switch 1 input at the sensor node
    - 1>SP1 output on when analogue reading is greater than set-point 1
    - 1<SP1 output on when analogue reading is less than set-point 1
- Press SW1 to reach the 'Output #2' menu.
- Pressing SW2 will cycle through the options for output 2, where IN2 is switch 2 at the sensor node and SP2 is set-point 2, a second analogue threshold:
    - = IN2
    - 1>SP2
    - 1<SP2
- Press SW1 to reach the 'Output #3' menu.
- Pressing SW2 will cycle through the options for output 3, where IN3 is switch 3 at the sensor node and SP3 is set-point 3, a third analogue threshold:
    - = IN3
    - 1>SP3
    - 1<SP3
    - 1>SP2 0<SP1
    - 1<SP1 0>SP2
- Press SW1 to reach the 'Output #4' menu.
- Pressing SW2 will cycle through the options for output 4, where IN4 is switch 4 at the sensor node and SP4 is set-point 4, a fourth analogue threshold:
    - = IN4
    - 1>SP4
    - 1<SP4
    - 1>SP4 0<SP3
    - 1<SP3 0>SP4

Set-points are shown as integer percentages of the full analogue input range. Each set-point has a hysteresis band of 5% to prevent rapid changes of the output when the input is hovering around the threshold. The latter two options for outputs 3 and 4 allow the hysteresis to be user-defined and greater than 5%. These options are best explained with the aid of the following diagrams.

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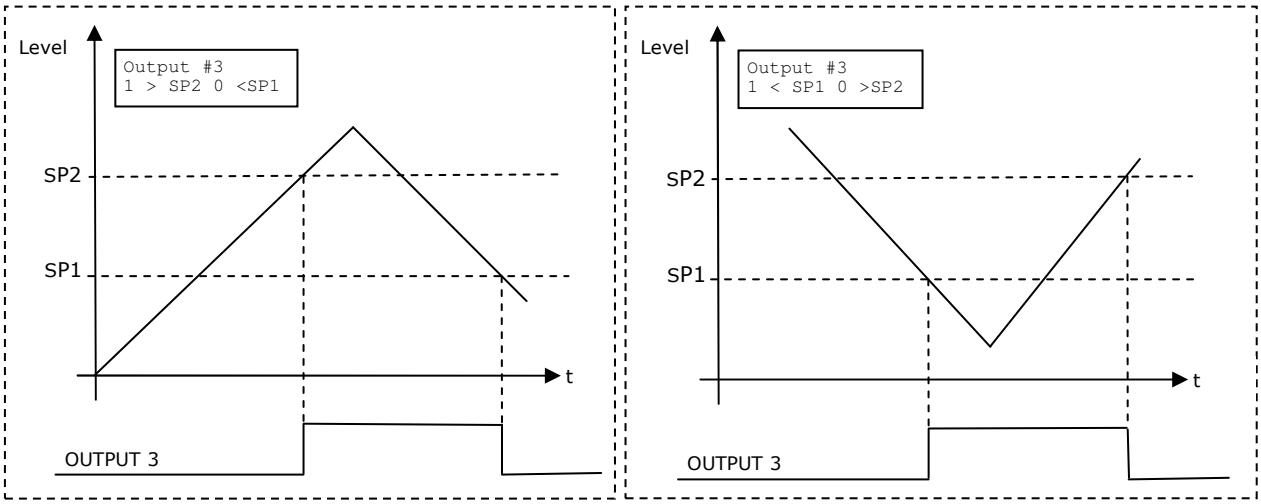

Figure 10: Setting hysteresis for Output 3

- Press SW1 to reach the 'SP1' menu
- Pressing SW2 increments the set-point and pressing SW3 decrements the set-point value in 1% steps.
- Press SW1 to reach the 'SP2' menu, then SW2 or SW3 to change Set-Point 2.
- Repeat for Set-Point 3 and Set-Point 4.

Note that SP2 will always be at least 5% greater than SP1, SP3 at least 5% greater than SP2, and SP4 at least 5% greater than SP3.

- Press SW1 to reach the 'Save Settings' menu. This will only appear if settings have been changed.
- Press SW2 to save. To exit without saving press SW3 or allow the screen to time-out.

Saving new settings will cause the Base Station to reset.

3.1.7 Other Configuration Settings and Menu Options

Network Device Registration

Deeter supply the Base Station and sensor node device (Sender or LVCS-RF) in sets already registered to work with one another as a network. If adding a Router, or reconfiguring the network for other reasons, refer to the section *Registering Network Devices*.

RF Channel

There are 16 channels in the 2.4GHz ISM band numbered 11 to 26. The 'Auto' setting will cause the Base Station to scan all channels and select the one with the least background activity at that time. This initial channel may subsequently change during operation if the system experiences poor communications.

The initial channel will be set during the registration procedure performed by Deeter. Changing the channel will not be necessary unless the user has a preference e.g. if they know of channels that are prone to interference. To select a new RF channel:

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- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup.
- Press SW1 to get to the 'Base Station Channel:' screen.
- Press SW2 to select a new channel.
- Press SW1 to get to the 'Save Settings' screen.
- Press SW2 to save or SW3 to exit without saving.

Transmit Interval

Changing the update rate is best left until after the network is installed and working satisfactorily with the default transmit interval. See section *Setting the Transmit Interval* for details of how to change settings.

Analogue Calibration

The 4-to-20mA analogue input to the Wireless Sender is calibrated during manufacture and should not require recalibration. If for some reason recalibration is necessary, the procedure is described in *Analogue Calibration,* below.

Transmit Power

The transmit power can be changed and is described in the section *Network Testing* below. The default power setting will be restored on any device reset.

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3.2 Wiring the Sender

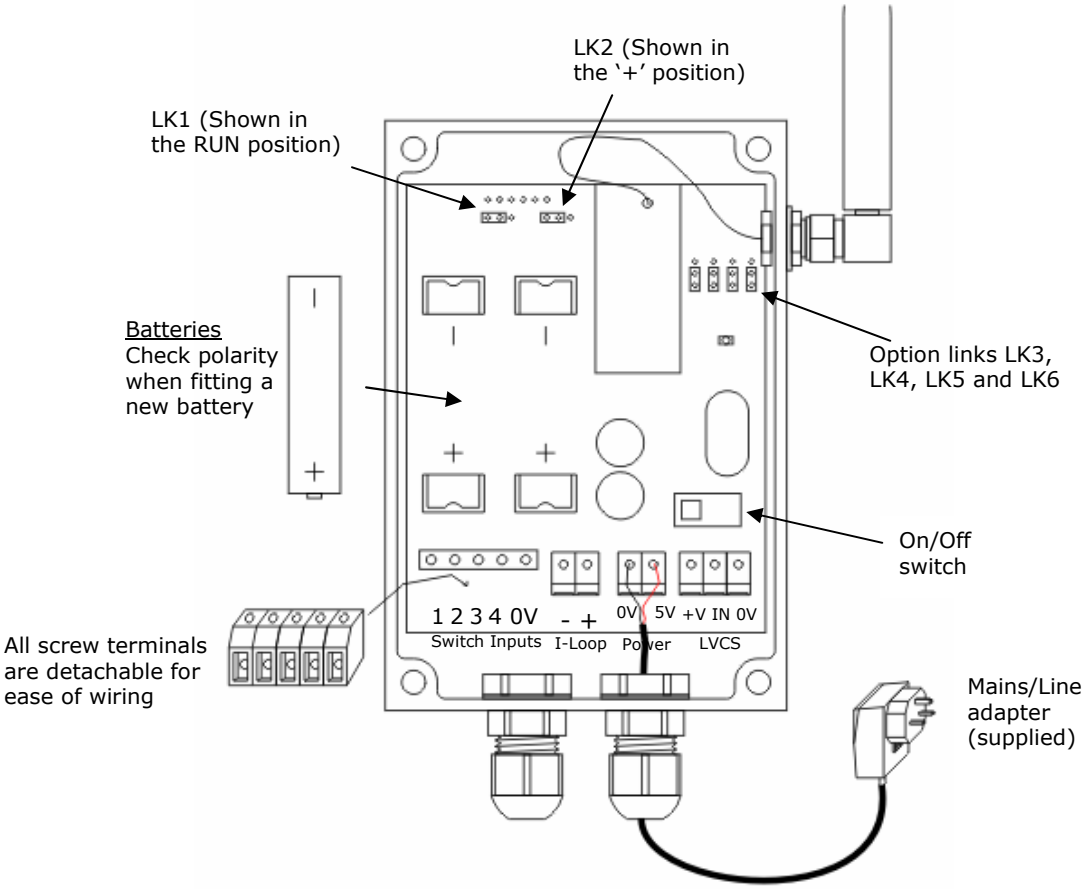
LK2 (Shown in the '+' position)
LK1 (Shown in the RUN position)
Batteries
Check polarity when fitting a new battery
Option links LK3, LK4, LK5 and LK6
On/Off switch
All screw terminals are detachable for ease of wiring
1 2 3 4 0V - + 0V 5V +V IN 0V
Switch Inputs I-Loop Power LVCS
Mains/Line adapter (supplied)

Figure 11: Connections to the Wireless Sender

All connections are via screw terminals and care must be taken to observe the correct polarity of signals.

If using the 5V power adapter supplied with the Sender, the +5V wire is indicated by a red sleeve.

Jumper link LK1 is reserved for programming the device and must be left in the RUN position. LK2 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

There are two options for the analogue input, either from a 4-to-20mA current-loop circuit or from a resistive sensor (e.g. Deeter resistive LVCS). The two options cannot be operated at the same time. Jumper link LK3 is used to select the analogue input; fit between pins 1-2 (upper position) to select the LVCS (resistive) input and between 2-3 (lower position), for the current-loop option.

If the Sender is battery operated, to help conserve the battery it is best to power on other devices in the network (Base Station and Routers) before powering on the Sender. With the battery in place, move SW1 to the on position. Observe the LED – this will come on for long bursts until wireless communications are established, then it will flash periodically.

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3.3 Fitting the LVCS-RF

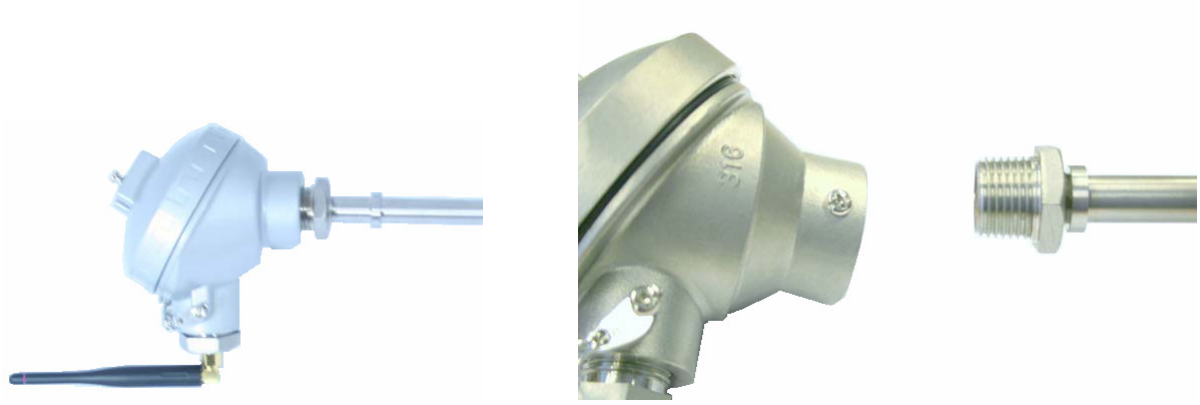

Figure 12: Separating the LVCS-RF Head and Stem

During installation it will be necessary to separate the head from the stem and the 3-way connector (J2) must be disconnected and re-connected afterwards. This should be done by feeding the connector carefully past the PCB without removing the PCB or disturbing the antenna lead.

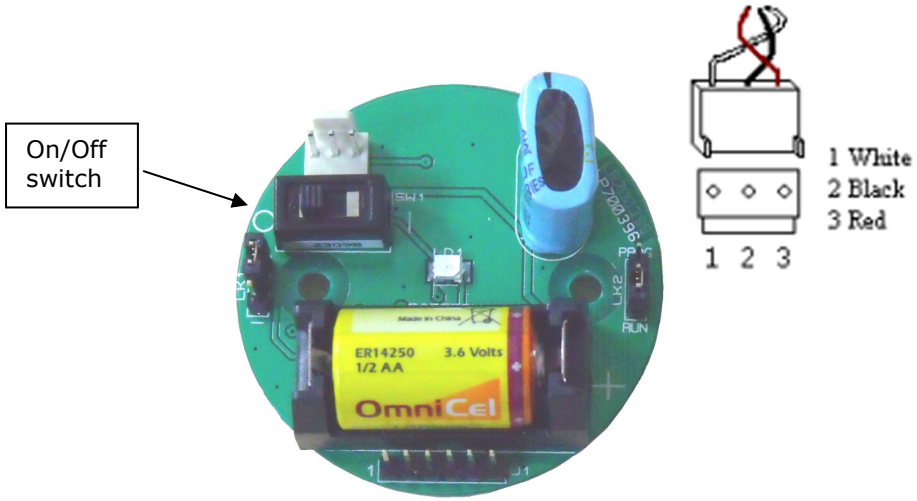

Figure 13: Reconnecting J2

The LVCS-RF has no external wiring (apart from the optional antenna extension kit).

Jumper link LK2 is reserved for programming the device and must be left in the RUN position. LK1 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

To help conserve the battery, it is best to power on other devices in the network (Base Station and Routers) before powering on the LVCS-RF. With the battery in place, move SW1 to the on position. Observe the LED – this will come on for long bursts until wireless communications are established, then it will flash periodically.

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3.4 Placing a Router

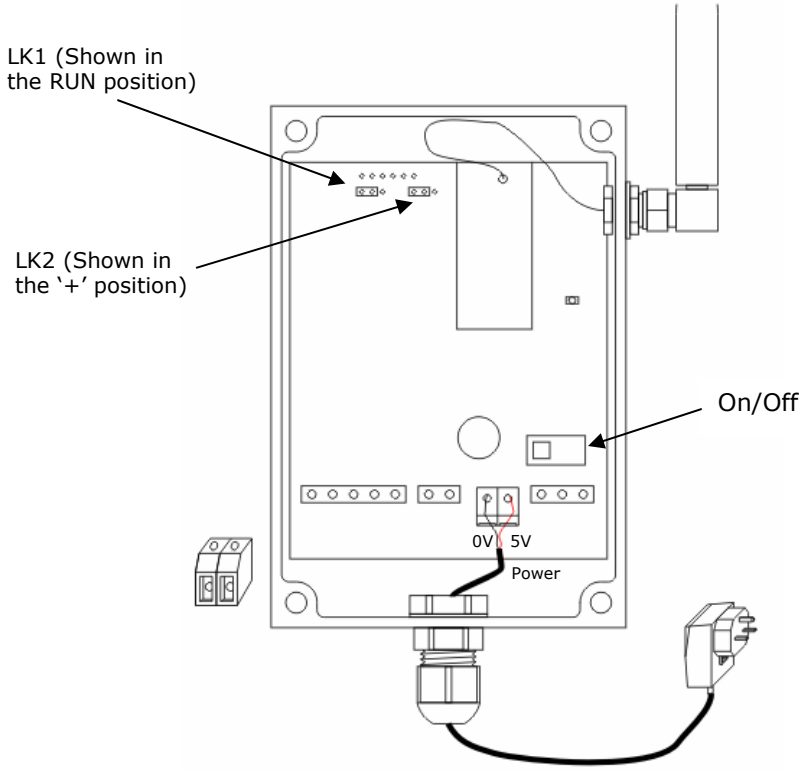

Figure 14 Wireless Router connections

The Router is supplied with a 5Vdc power supply. Feed the cable through the cable gland and connect the two wires to the screw terminal. The +5V wire has a red sleeve.

Jumper link LK1 is reserved for programming the device and must be left in the RUN position. LK2 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

The Router must be registered to operate with a Base Station and this process is best performed close to the Base Station before installing the Router in its final location. See *Registering Network Devices* for details of how to register a device.

Up to four Routers may be used in a single system, with data messages passing in several hops between the remote sensor node and the Base Station. The Routers should be placed approximately equidistant between remote sensor and Base Station. It may be better to place a Router off to one side of the direct line between devices when there are obstructions in the direct path.

3.5 Antenna Location

For optimum range and reliable network connection, antennae should be placed as high as practical and pointed vertically. The recommended height for antennae at a range of 400m is 2.4m. An optional extension lead and bracket kit is available to help achieve a higher mounting for the antenna.

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3.6 Antenna Installation Precautions

These devices operate at very low transmit power compared with mobile/cellular telephones and other similar portable devices. However regulatory precautions require that devices must not be placed so that the antennae are closer than 200mm from any person.

3.7 Registering Network Devices

The Deeter Wireless Base Station acts as the coordinator for an IEEE 802.15.4 wireless network. All devices on this network and any others that might be operating in the vicinity are identified by a unique MAC address. The Base Station starts the network and the other devices join the network in turn.

In order for the sensor node, either a Sender or an LVCS-RF, to send its data only to the intended Base Station, a registration process must be carried out. This only needs to be done once. It is recommended that the Sender or LVCS-RF is registered with its Base Station on the bench in close proximity before it is installed in its final operating position.

The Wireless Routers need to be registered with the Base Station so that they only join the intended network.

Once these devices have been registered with their network they will be automatically allowed to rejoin after any power interruption or temporary loss of radio contact.

To make the process of installation easy for the customer, Deeter supply the Base Station and sensor node device (Sender or LVCS-RF) in sets already registered with each other and ready to communicate. Unless adding a Router or reconfiguring the network from scratch, the rest of this section may be skipped.

To clear previous network settings on the Base Station:

- Move link LK1 to the '–' position.
- Power on the Base Station and wait a few seconds until the LED stops flashing.
- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the 'Reset System' screen
- Press SW2 to clear network settings.
- Move link LK1 back to the '+' position.

To clear previous network settings on a Sender, Router or LVCS-RF:

- Power off the device
- Move link LK1 (LVCS-RF), LK2 (Sender and Router) to the '–' position
- Power on the device
- Move the link back to the '+' position.

To register network devices

- Power on the Base Station and wait a few seconds until the LED stops flashing.
- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the 'Register' screen
- Turn on the device that is to join the new network
- Press SW2 to start the registration process.

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The screen will show 'Allow join:' and a countdown in seconds of the time left for this process. If a new device joins during this time, the MAC address of the device will be shown on the screen. If unsuccessful, press SW2 again to repeat the process. If still unsuccessful, it may be because the device is already registered to another network – make sure settings have been cleared using the procedure described above.

To register another device (for systems with Routers), re-enter the 'Register' screen and press SW2 to repeat the process.

3.8 Network Testing

Power-on all network devices. After a brief pause the Base Station will automatically start the network. (If the Base Station 'Option Link' is in the '—' position it will be necessary to press SW1 to start. Move the link to the '+' position before completing the installation). Devices within range will join the network and establish a route automatically.

Successful connection of the Sender, LVCS-RF and Router will be indicated by a flash of the LED once every two seconds (the default transmit interval). Unsuccessful connection will be indicated by long bursts of LED activity.

At the Base Station, the display cycles through a number of screens. The one that shows 'Sensor Node' will also show the words 'Running' for a successful connection, 'Timeout' for an unsuccessful connection, or 'Not Registered'. If 'Not Registered' is displayed, then a Sender or LVCS-RF has not been registered with the network – see *Registering Devices* above.

If the Sender or Base Station indicate an unsuccessful connection, it may be necessary to reduce the distance between devices, move or adjust the antennae, or add one or more Deeter Wireless Routers to the network.

Once all devices are successfully connected, the next step is to determine the strength of the wireless links. If connections are borderline, minor disturbances to the environment could cause the network to break up.

A measure of the radio reception strength is called the "Link Quality Indicator" or LQI. This number will be displayed at the Base Station next to the word 'Running' in the 'Sensor Node' screen. (Pressing SW1 several times will reach a screen showing 'Node # 1 Last LQI' for a static display of the LQI.) The number shown will range from 0 to 255, with higher numbers indicating a stronger link.

The default transmission power is +6dBm which is good for a range up to 1000m in open-field conditions and an antenna height of 2.4m or more. For network testing, the strength should be reduced to 0dBm to see whether it will work at lower power.

If the network continues to work at this reduced power, there will be greater confidence that it will operate under worse environmental conditions (wet or cold weather conditions, RF interference, objects moving between antennae, weak

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battery, etc.). If the network fails to operate at reduced power, try relocating the antennae to improve the signal quality, or add a Router to the network.

Further successful connections at -6dBm and -12dBm would add to confidence levels in the network. Looking at the LQI figure for each power level will provide an indication of how close to break-up the network is. With an LQI below approximately 60 the next lower level is unlikely to work.

To set the transmit power level:

- Press SW1 on the Base Station until the display shows 'Sensor Node <Setup>'.
- Press SW2 to enter Sensor Node setup
- Press SW1 until the 'Node #1 Power' screen is shown.
- Pressing SW2 will cycle through the power options
- Pressing SW3 will set the new power level.

The transmit power level of the remote devices is changed after receipt of a message from the Base Station. If the network breaks-up at a lower level, it may prove impossible to set a higher level again from the Base Station. In this case it will be necessary to power off and back on all remote devices to restore the default.

At the end of network testing, remember to set the transmit power back to +6dBm.

3.9 Setting the Transmit Interval

The choice of transmit interval will be crucial to determining battery life for an LVCS-RF and for a battery-only powered Sender. Longer intervals will extend the battery life but may not be suitable for some systems – the installer must decide on the best compromise between transmission rate and battery life.

The following time interval settings are available:

- 1 second
- 2 seconds
- 5 seconds
- 10 seconds
- 20 seconds
- 30 seconds
- 60 seconds

For update intervals over 5 seconds, the sensor node sends synchronising pulses at 5 second intervals between updates. These are shorter, less energy consuming pulses. If switch inputs change or analogue inputs change by more than 5%, a data pulse will replace the synchronising pulse, thus making updates at a maximum of 5 second intervals. The advantage of setting a time of 5, 10, 20 or 30 seconds over 60 seconds only applies to slowly changing analogue inputs, where small changes will be transmitted more frequently than every 60 seconds.

The transmit interval is set at the Base Station but saved in non-volatile memory at the sensor node. To change the transmit interval:

- Press SW1 until the display shows 'Sensor Node <Setup>'.
- Press SW2 to enter Sensor Node setup.
- Press SW1 to get to the 'Node #1 Rate' screen.
- Press SW2 to cycle through the available time settings.
- Press SW3 to select the new transmit interval.

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3.10 Analogue Calibration

The 4-to-20mA analogue input to the Wireless Sender is calibrated during manufacture and should not require recalibration. However, a calibrations option is available on the Base Station display menu and the recalibration procedure is described here.

If the sensor node is an LVCS-RF or a Wireless Sender set for analogue resistive input (LK3 in the upper position), calibration is not possible or necessary. The analogue readings can be viewed on the Base Station display but the following calibration procedure will not change anything.

- Press SW1 to get to the 'Sensor Node <Setup>' screen
- Press SW2 to enter Sensor Node setup
- Press SW1 to get to the 'Node #1 Level' screen.

The 'Node #1 Level' screen shows the present analogue reading it is receiving from the sensor node as a fraction of 200, e.g. 100/200. Calibration will only be possible if the readings are within 5% of the lower or upper limits, i.e. <10/200 and >190/200.

- Set the current loop input to the Sender to 4mA.
- If the display shows 0/200 recalibration is not necessary.
- Pressing SW3 will save a new setting for the low end of the analogue input range and the screen will return to normal display mode.
- Re-enter 'Node #1 Level' screen and observe that the display now indicates 0/200. Set the current loop input to the Sender to 20mA.
- If the display shows 200/200 no calibration is necessary.
- Pressing SW3 will save a new setting for the high end of the analogue input range and the screen will return to normal display mode.
- Re-enter 'Node #1 Level' screen and observe that the display now indicates 200/200.

Calibration data is transmitted to the Sender and saved in non-volatile memory so calibration should only need to be performed once.

3.11 Low Battery Indication

The expected life of a LVCS-RF battery is greater than 6 months with a transmit interval of 5 seconds and infrequent breaks in the wireless network. The Sender AA size battery has twice the capacity and is expected to last more than 12 months at the same transmit interval. (A 'C' size battery option is available for the Sender on request. This has approximately 3 times the capacity of an AA cell.)

The sensor node measures its supply voltage and transmits this information to the Base Station for display. The Base Station will flash the voltage to indicate a flat battery when the readings go below a threshold.

Lithium thionyl chloride battery discharge characteristics are complex and the threshold chosen is best suited to a network that doesn't suffer frequent communications loss. Normal operating current drain is measured in micro-amps and the battery will maintain a high voltage almost up to the end of its life.

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Therefore, with good RF communications the battery will continue to work for several days after the low-battery threshold is reached. However, if the radio network should break-up when the battery is near the end of its life, current consumption will increase and cause the battery voltage to collapse. Under these conditions there may be little or no warning of imminent battery failure.

When replacing batteries pay particular attention to fit the batteries the correct way round – the positive terminal is marked with a '+' on the circuit board or battery holder. Replace only with lithium thionyl chloride batteries with a 3.6V (nominal) cell voltage. (Standard Lithium batteries or rechargeable cells will not work). See *Replacing Batteries* in the *Warnings* section below.

3.12 Loss of Radio Link

If the Base Station loses contact with the sensor node it will display the message 'Sensor Node Strike 1', followed by 'Strike 2', and eventually 'Timeout'. At this point the transistor outputs will be turned off and the 4-to-20mA output will go to zero milliamps; a level recognised by many current loop devices as a fault condition.

If the link is not re-established quickly, the Base Station will scan all RF channels and choose a new one that has low background activity. If, for example, the link was broken due to the sensor node being switched off, when it is powered back on it will initially try the last known channel (this minimises power consumption at start-up), then if the link is not re-established it will scan all channels and make contact on the new channel.

Once communications are re-established, Base Station outputs will be restored to match the sensor node inputs.

If communications break-up on a regular basis it may be necessary to check the installation again – see *Network Testing*. Perhaps the sensor node battery is low – see *Low Battery Indication*. Other solutions include moving the antennae to improve the link quality or adding a Router to the system.

Note: wireless devices are not recommended for safety-critical applications, unless additional measures are taken to mitigate the consequences of a loss of communications.

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4. Specifications

4.1 Wireless Base Station

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26
Transmit power:	Model BE01: 6dBm (to comply with ETSI limit) Model BU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Supply Voltage	12V DC unregulated, external mains adapter (supplied)
Minimum supply voltage	10V DC
Maximum supply voltage	26V DC

Process Outputs

Discrete outputs	four open-collector transistor outputs (maximum current sink 50mA, maximum voltage 40VDC, for resistive loads)
Analogue outputs	4-to-20mA current loop

Communications

Serial communications port	One UART Low voltage (internal connector J5), or RS232 (full duplex), or RS485 (half duplex, future software feature)
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 179mm, Width 138mm, Depth 51mm
Antenna	Height 88mm

Regulatory Compliance

Base Station Model BE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model BE01 is CE marked for sale in Europe. Model BE01 also complies with FCC Part 15 regulations.
Base Station Model BU01	A higher power model BU01 is available, which also complies with FCC Part 15 regulations. Model BU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

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4.2 Wireless Sender

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26
Transmit power:	Model SE01: 6dBm (to comply with ETSI limit) Model SU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Battery Type	Lithium Thionyl Chloride
Battery Voltage	3.6V nominal
Battery Size	AA
External Supply Voltage	5V DC unregulated, external mains adapter (optional)

Process Inputs

Discrete inputs	four voltage free contact switched input (sense voltage 3.3V nominal, maximum contact resistance 1k Ω)
Analogue inputs	potentiometer type (10k Ω minimum) 4-to-20mA current loop (sense resistor 100Ω)

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J5),
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 160mm, Width 120mm, Depth 62mm
Antenna	Height 88mm

Regulatory Compliance

Sender Model SE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model SE01 is CE marked for sale in Europe. Model SE01 also complies with FCC Part 15 regulations.
Sender Model SU01	A higher power model, which also complies with FCC Part 15 regulations. Model SU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

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4.3 LVCS-RF Continuous Liquid Level Sensor Transmitter

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26
Transmit power:	Model LE01: 6dBm (to comply with ETSI limit) Model LU01: 18dBm (max)
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Battery Type	Lithium Thionyl Chloride
Battery Voltage	3.6V nominal
Battery Size	½AA

Process Inputs

Analogue inputs	potentiometer type

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J1),
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 125mm, Width 85mm, Depth 55mm
Antenna	Height 88mm

Regulatory Compliance

LVCS-RF Model LE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model LE01 is CE marked for sale in Europe. Model LE01 also complies with FCC Part 15 regulations.
LVCS-RF Model LU01	A higher power model, which also complies with FCC Part 15 regulations. Model LU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

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4.4 Wireless Router

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26
Transmit power:	Model RE01: 6dBm (to comply with ETSI limit) Model RU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

The Router must be continuously powered from an external supply.

External Supply Voltage	5V DC unregulated, external mains adapter (supplied)

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J5)
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 160mm, Width 120mm, Depth 62mm
Antenna	Height 88mm

Regulatory Compliance

Router Model RE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model RE01 is CE marked for sale in Europe. Model RE01 also complies with FCC Part 15 regulations
Router Model RU01	for use where the local regulations allow a higher transmitted radio power. Model RU01 complies with FCC Part 15 regulations. Model RU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

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5. Warnings

5.1 Replacing Batteries

The batteries in the Wireless Sender and LVCS-RF are high power Lithium Thionyl Chloride primary cells. These must not be recharged. Replace only with equivalent parts as the system requires the higher 3.6V (nominal) cell voltage. Standard Lithium batteries or rechargeable cells will not work. Pay particular attention to fit the batteries the correct way round. The positive terminal is marked with a '+' on the circuit board or battery holder.

5.2 Fuses

The Base Station fuse is a 500mA anti-surge, socketed surface-mount type from Littelfuse (manufacturer's part number 0154.500DRT). Replace the fuse with the same type.

5.3 Antenna

The system can only be used with the antennae supplied. Any attempted use with unapproved antenna types will invalidate the system compliance and may be illegal.

5.4 CE Marking

The models approved for use within the European Union bear the CE mark to show compliance with EU Directives and European regulations. In particular the maximum RF transmission power is limited to 6dBm in order to comply with ETSI regulations.

5.5 FCC Part 15 Compliance

The system uses an RF Transceiver module that complies with US Federal Communications Commission Part 15 Regulations for intended RF emissions.

Each device is permanently labelled with the following statement.

Contains:
FCC ID TYOJN5139M4
IC 7438A-CYO512M4

This covers the following module variants: JN5139-001-MØ4 and JN5139-Z01-MØ4.

This compliance requires the use of the approved antenna supplied.

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5.6 RF Exposure Compliance

The RF Transceiver Module has been granted FCC Modular Approval for mobile RF Exposure conditions. This grant requires that the antenna used for this transmitter must be installed to provide a separation distance of at least 200mm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

The user must not attempt to remove or install the RF Transceiver. Apart from battery and fuse, there are no user serviceable parts in any of the Deeter Wireless Sensor devices.

5.7 Repair and Servicing

Do not attempt to repair this product yourself. Contact the Deeter Group for product servicing or repairs.

5.8 Disposal and Recycling

Dispose of used batteries according to local regulations.

At the end of the equipment life the product should be recycled according to the European Directive on Waste Electronic Equipment.

Outside the EU dispose of this product according to local recycling or waste disposal regulations.

This equipment is expected to have a long service life and the regulations will most likely change during that time.

This product must not be disposed in household waste.

6. List of Acronyms and Abbreviations

MAC	Media Access Control, network protocol layer
IEEE	The Institute of Electrical and Electronic Engineers, website www.ieee.org
IEEE 802	The IEEE standards for Local Area Networks
ISM	Industrial, Scientific and Medical, allocated frequency bands
dBm	power measurement expressed in decibels referenced to 1mW +6 dBm is 4mW 0 dBm is 1mW -6 dBm is ¼ mW
LVCS	Liquid Vertical Continuous Sensor, a range of sensor made by Deeter
LQI	Link Quality Indicator, a number between 0 and 255 that provides some indication of the radio signal strength. High numbers indicate stronger signals.

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